UNITED STATES DEPARTMENT OF AGRICULTURE
Agricultural Marketing Service
Fruit and Vegetable Programs
Processed Products Branch

GENERAL MEMORANDUM NO. 17
April 2005

SUBJECT: **Tomato Products Spectrophotometer Studies**

TO: All Branch Personnel

In December 2002, Processed Products Branch (PPB) in cooperation with the University of California, Davis (UCD) completed a study of spectrophotometers for use in the evaluation of "color" in tomato products. The study was initiated to consider additional instruments for approval at the request of instrument suppliers. PPB currently maintains a list of approved instruments including the HunterLab D25-D2 series; Agtron M400, M500, and E5M Colorimeters; and BYK Gardner models XL20, XL23, XL-805, and Colorgard 2000/05.

The study compared the ColorFlex 4500L, Labscan XE, and the D25A-9000 measuring devices from HunterLab and the Color View measuring device from BYK Gardner to the UCD reference spectrophotometer (HunterLab LabScan 5100).

Samples of commercially prepared tomato products were purchased from grocery stores in the Davis, Sacramento, and Vacaville, CA and Reston, VA areas. The illuminant used for the color study was CIE illuminant C. The standard observer was 1931, 2 degrees Standard Observer and the Color Scale was Hunter L, a, b or L*a*b* (BYK Gardner).

As a result of the study completed in 2002, and determinations made by PPB, the following spectrophotometers and the equations associated with each instrument are approved for the calculation of the color score for products covered by the U.S. Standards for Grades of Canned Tomato Sauce, Tomato Juice, Tomato Juice from Concentrate, Tomato Paste, Tomato Puree, Concentrated Tomato Juice, and Tomato Catsup .

BYK Gardner Color View

Tomato Sauce Score: TSS = -227.607 + 1.154(a) + 33.615(b) -1.278(b^2)
Tomato Catsup Score: TCS = -59.387 + 5.635(a) - 0.0990(a^2) + 0.414(b)
Tomato Juice Score: TJS = 95.652 + 0.956(a) - 11.840(b) + 0.379(b^2)
Tomato Paste and Puree Score: TPS = -2.63270 + 13.822(log b) - 7.422(log L) + 0.0234 (a) - 1.002(b) + 0.295(L);

where L, a, and b are readings reported by the instrument.

HunterLab ColorFlex

Tomato Sauce Score: TSS = -153.100 + 1.187(a) + 22.332(b) - 0.864(b^2)
Tomato Catsup Score: TCS = -80.888 + 8.355(a) - 0.144(a^2) - 1.194(b)
Tomato Juice Score: TJS = 25.963 + 0.989(a) - 1.787(b)
Tomato Paste and Puree Score: TPS = -81.582 + 1.069(a) + 15.390(b) - 0.591(b^2)

Hunter D25A-9000

Tomato Sauce Score: TSS = -180.263 + 1.145(a) + 26.413(b) - 1.012(b^2)
Tomato Catsup Score: TCS = -99.999 + 9.532*(a) - 0.166*(a^2) - 0.936(*b)
Tomato Juice Score: TJS = 25.715 + 0.956(a) - 1.748(b)
Tomato Paste and Puree Score: TPS = -58.296 + 1.093(a) + 12.120(b) - 0.480(b^2)

HunterLab Labscan XE

Tomato Sauce Score: TSS = -149.176 + 1.139(a) + 21.608(b) - 0.826 (b^2)
Tomato Catsup Score: TCS = -81.964 + 8.321(a) - 0.142(a^2) - 1.129(b)
Tomato Juice Score: TJS = 25.114 + 0.939(a) - 1.638(b)
Tomato Paste and Puree Score: TPS = -40.926 + 1.061(a) + 9.473(b) - 0.376(b^2)

The following equations are used for the calculation of color score for the previously approved colorimeters for tomato products. [1]

Hunter D25-D2 Colorimeter

Tomato Sauce Score: TSS = -154.39 + 1.1142(a) + 22.596(b) - 0.86736(b) [2]
Tomato Catsup Score: TCS = -74.937 + 7.5172(a) - 0.1278(a)^2 - 0.8051(b)
Tomato Juice Score: TJS = 29.600 + 0.8835(a) - 1.8553(b)
Tomato Paste and Puree Score: TPS = -46.383 + 1.0211(a) + 10.607(b) - 0.42198(b) [2];

[1]These equations are based on Hunter a and b values referenced in the initial study by USDA at UC Davis entitled, "Color Scoring Tomato Color Measure", by George Marsh, James Buhlert, Sherman Leonard, Teri Wolcott and Julie Heil, Dept. of Food Science and Technology, University of California, Davis, July 15, 1980. Copies are available from PPB upon request.

Agtron M400 and M500 Colorimeters

Tomato Sauce Score (tentative): TSS = -25.002 + 1.5234(R) - 0.0092174(R^2) - 0.25817(G)
Tomato Catsup Score (tentative): TCS = -5.3411 + 1.0309(R) - 0.00745(R^2) - 0.15663G
Tomato Juice Score: TJS = 28.629 + 0.14286(R) - 0.24197(G) + 0.14176(B)
Tomato Paste and Puree Score: TPS = 20.850 + 0.828(R) - 0.004335 (R^2) - 0.283 (G) + 0.312(B)

R = Red, G = Green, B = Blue

Agtron E5M Colorimeters

Tomato Sauce Score (tentative): TSS = 38.936 - 0.45231(E5M Reading)
Tomato Catsup Score: TCS = No equation is available for an accurate color score for catsup.
Tomato Juice Score: TJS = 40.898 - 0.35759 (E5M reading)
Tomato Paste and Puree Score: TPS = 54.250 - 0.005265 (E5M Reading)^2

For Tomato Paste and Puree having a brown or burnt visual appearance the Agtron E5M meter reading yields accurate "substandard" scores.

BYK Gardner XL20, XL23, XL-805, and Colorgard 2000/05 Colorimeters

Tomato Sauce Score (tentative): TSS = -193.20 + 1.0211 (a_L) + 27.649(b_L) - 1.0175(b_L) ^{2}
Tomato Catsup Score: TCS = -40.511 + 4.7767(a_L) - 0.07791(a_L^2) - 0.56986(b_L)
Tomato Juice Score: TJS = 34.094 + 0.71464(a_L) - 1.7883(b_L)
Tomato Paste and Puree Score: TPS = -46.383 + 1.0211(a_L) + 10.607(b_L) - 0.42198(b_L) ^{2};

where a_L and b_L are readings reported by the instrument.

RETAIN THIS GENERAL MEMORANDUM WITH FILE CODE SECTION 104 AND WITH THE INDIVIDUAL COMMODITY FILES FOR TOMATO PRODUCTS.

Terry B. Bane
Branch Chief

Distribution: A
Agriculture: Washington

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